The Diets of Sympatric Juvenile Skinks *Ctenotus robustus* and *Ctenotus taeniolatus* on Coastal Sand Dunes in New South Wales

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INTRODUCTION

Despite the genus *Ctenotus* (Scincidae) being one of the most diverse genera of Australian lizards with more than 70 species currently described (Cogger 1986), there have been few ecological studies. Pianka (1969) compared the ecology of 14 sympatric species of *Ctenotus* in the Great Victoria Desert and James (1989) compared the ecology of sympatric *Ctenotus* in spinifex grasslands in central Australia. However, there is little information on the diet of juveniles of these two species, and none on the diet of these skinks in coastal habitats. Here, we present limited data on the diet of juveniles of two coexisting species, *C. robustus* and *C. taeniolatus*.

STUDY SITE

The skinks were sampled on a regenerating mining path near the Big Gibber (BG) headland in the Myall Lakes National Park, New South Wales situated approximately 300 km north of Sydney. The relative mean abundance of adult skinks was approximately four *C. robustus* and two *C. taeniolatus* on each of the four 1 ha study sites considered here (Twigg and Fox, unpublished data). The vegetation on the reconstructed coastal sand dunes regenerates after mining as shrubland, with some emergent eucalypt trees appearing in later years. Regeneration age at this time ranged from 9.3 y (BG1) to 15.0 y (BG8). The mining path is between 100 and 200 m in width and spreads like a long ribbon through the unmined open sclerophyll forest in this area which is dominated by *Angophora costata* and *Eucalyptus pilularis*, with a heath type understorey (Fox and Fox 1984).

SAMPLING STRATEGIES

Skinks were collected from the regenerating path from 31 March to 3 April, 1987, in pitfall traps (120 mm dia. × 77 mm; containing 300 ml of 70% (v/v) ethanol) which had been set as part of a project to sample the invertebrate fauna on the mining path. These traps were 5 m apart in a 3 × 3 grid with three replicates on each 1 ha site and were open for three consecutive days. Snout-vent lengths of the skinks in our study show them to be juveniles that had hatched one to three months prior to their collection (C. James, pers. comm.). The mean and standard error (range) of the snout-vent lengths for the *C. robustus* and *C. taeniolatus* were: 41.2 ± 1.2 (36.6-49.9) mm and 34.3 ± 0.87 (29.7-38.8) mm respectively. Initially, skinks were kept in 10% formalin (one to two weeks) and then transferred into 75% ethanol. After a further two to three weeks, the stomach of each skink was removed and its contents extracted into 75% ethanol. Stomach contents were identified using both our reference collection for Myall Lakes and the descriptions and illustrations given by CSIRO (1970). The percentage occurrences of diet items in stomachs were compared between species as well as with the relative biomass for orders of arthropods encountered in the pitfall traps. These occurrences were also tested for significant differences in diet between species.

RESULTS AND DISCUSSION

The data from the pitfall trapping are shown in Fig. 1A, arranged in descending rank which was also used for presentation of diet items for the two skink species. The stomachs of 10 *C. robustus* and 11 *C. taeniolatus* contained invertebrates from 11 and nine orders respectively, with eight orders common to both species (Fig. 1A). With the exception of one *C. taeniolatus* no empty stomachs were found and virtually all dietary items could be identified. Sand, plant material and sloughed lizard skin were recorded in stomachs of both species. For coleopterans and lepidopterans it was possible to identify larvae and these were considered separately.

The most abundant group in the pitfall traps were hymenopterans to which ants contributed over 99% of the biomass. Coleopterans, Arachnids and orthopterans were the next most abundant and were followed by dermapterans and diplodans which were not found in any stomachs. Dipterans were found in the pitfalls in reasonable numbers but there was only a very small contribution from the remaining groups: Hemiptera, Coleoptera larvae, Blattodea, Lepidoptera and Neuroptera, while all other groups found in stomachs were not represented in the pitfalls at all (Table 1). The ants in the stomachs of *C. taeniolatus* were all referable to *Rhytidoponera metallica* while *Iridomyrmex* sp. and *Pheidole* sp. were found in *C. robustus* stomachs, but, we have no explanation of why this should be so. We

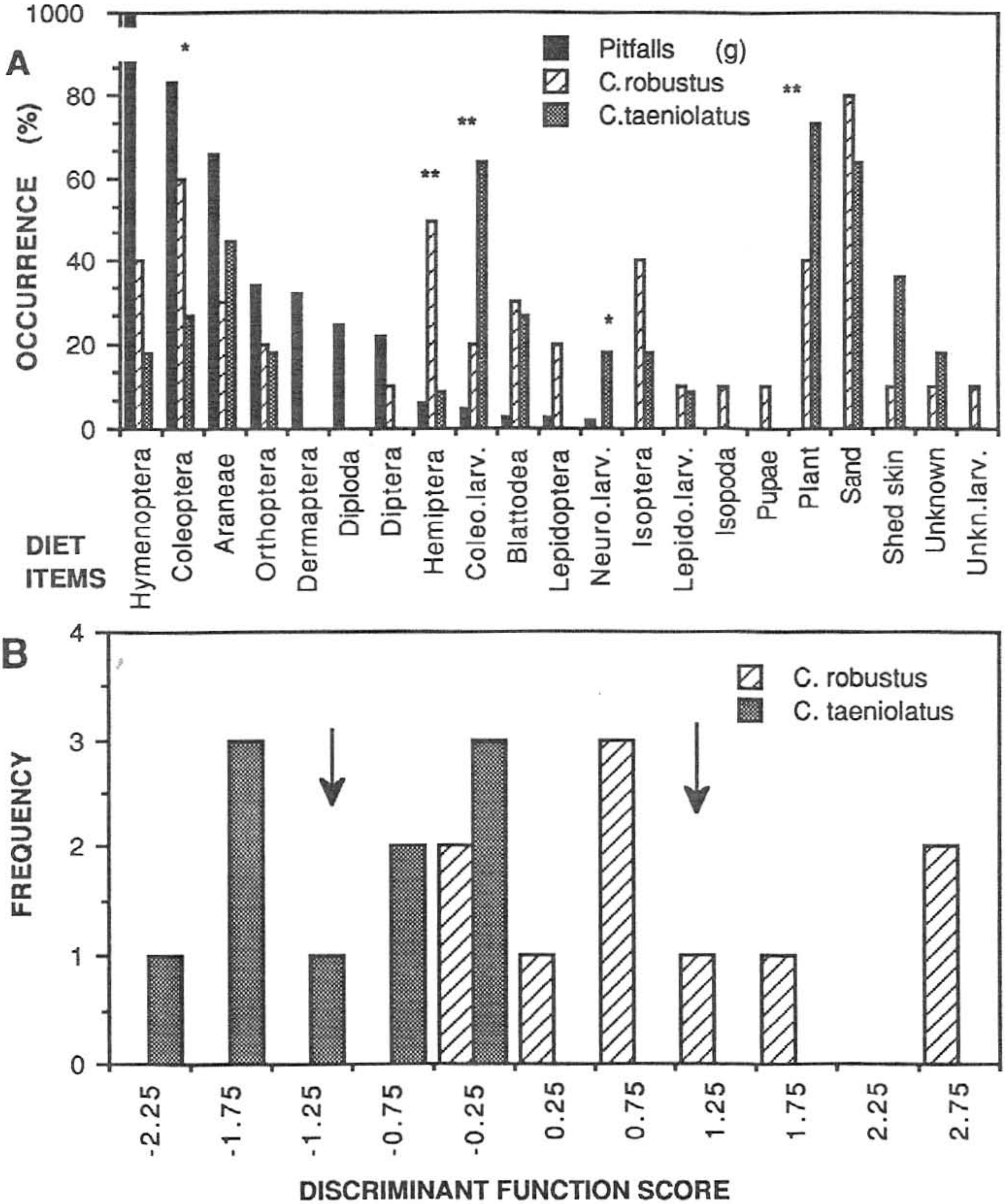

Fig. 1. A. The biomass (in grams, note the break in scale) of invertebrate groups found in pitfall traps from the study area, together with the occurrence (as a percentage) of each dietary category in the stomach contents of the two *Ctenotus* species. Significant differences between lizard species are indicated (*$p < 0.05$, **$p < 0.01$). Except for a single wasp in the stomach of one *C. robustus*, and less than 1% of the material in the pitfall traps, hymenopterans consisted entirely of formicids (ants). *B.* Discriminant function scores for the juvenile skinks illustrating the separation in their diets (see text for explanation of the procedure and the variables used). Arrows indicate position of group centroids for *C. robustus* and *C. taeniolatus*.

Table 1. Presence/Absence of food items of *Ctenotus taeniolatus* and *C. robustus* and pitfall data.

	C. taeniolatus No. of stomachs	*C. robustus*	Pitfalls
Insecta			
Diptera	0	1	P
Lepidoptera: adult	0	2	P
larvae	1	1	P
Coleoptera			
Carabidae	0	1	P
Anobiidae	0	1	P
Tenebrionidae	0	1	P
Elateridae	1	1	P
Scarabaeidae	3	2	P
Undet. larvae	7	2	P
Blattodea	3	3	P
Isoptera	2	4	A
Hemiptera			
Cicadellidae	1	1	P
Pemphigidae	0	4	A
Membracidae	0	1	A
Orthoptera	2	2	P
Neuroptera Myrmeleontidae — larvae	2	0	P
Hymenoptera: Formicidae	2	3	P
Tiphiidae	0	1	P
Arachnida			
Araneae: Thomisidae	0	3	P
Lycosidae	3	0	P
Isopoda	0	1	P
Unknown	2	1	—
Shed Skin	4	1	P
Unknown larvae	0	1	P
Sand/dirt	7	8	P

should also emphasize that ants occur in a very much smaller proportion of stomachs than would be expected from their overwhelming abundance in pitfall traps (Fig. 1A). The only other hymenopteran found was a single wingless female wasp (*Hemithynnus* sp.); it occurred in *C. robustus*. *Diaea* sp. (garden spiders; Thomisidae) occurred in the stomach of *C. robustus* while *C. taeniolatus* stomachs contained several lycosid specimens (wolf spiders). Representatives of both spider families commonly occur on the mining path (Fox *et al.*, unpubl. data). Termites were identified in the stomachs of *C. robustus* and *C. taeniolatus* and in both instances these consisted of imago workers and soldiers of the same termite species, *Nasutitermes* sp. (Termitidae). These termites are not represented in our invertebrate pitfall samples for this area. However, they are commonly found in trees in the undisturbed forest.

A discriminant function analysis using the Mahalanobis distance procedure (SPSS/X, 1983) was employed to examine the pattern of the separation between the diets of the two lizard species. Here, each diet category was recorded simply as present or absent for each skink with sand, lizard slough, unknowns and those categories which occurred once only being excluded. Because a large portion of the stomach contents of one *Ctenotus taeniolatus* could not be identified it was not included in the analysis. This analysis revealed that the diets of the two species were distinct. Figure 1B shows the histograms of the discriminant function scores calculated for the skinks. Ninety per cent of cases were correctly classified ($F = 5.58$, d.f. $= 4.15$, $P = 0.006$; Eigenvalue $= 1.49$) and group centroids were at plus and minus 1.157 for *C. robustus* and *C. taeniolatus* respectively. The variables in the equation and their correlation with the discriminant function were: coleopteran larvae (−0.477), hemipterans (0.398), neuropterans (−0.290) and other coleopterans (0.259).

Most invertebrates observed in the stomach contents of the juvenile *C. robustus* and *C. taeniolatus* commonly occur in the invertebrate pitfall traps (Fig. 1A). The

invertebrate orders represented in the stomachs of the juvenile *C. robustus* were similar to those found for other *Ctenotus* species (Pianka 1969). However, Brown (1983) found that 99% by volume of the identifiable items in the stomach contents of *C. taeniolatus* in northwestern Victoria consisted of food items from only three orders; Orthoptera (53%), Isoptera (30%) and Coleoptera (16%). This range of food items is considerably narrower than that found for *C. taeniolatus* in our data (Fig. 1A) and for most other *Ctenotus* species investigated (Pianka 1969).

Taylor (1986) also found that the major components by percentage volume (and percentage of stomachs) for *C. taeniolatus* from New England were lepidopterans 33 (14), orthopterans 28 (21), blattodeans 17 (7) and araneaeans 12 (36). Coleopterans 3 (14), hemipterans 0.3 (14) and isopterans 0.2 (7) were minor components of the stomach contents of the 14 juvenile lizards she examined. While our data on the percentage of stomachs containing each prey category are more similar to the range found by Taylor (1986), juvenile *C. taeniolatus* at Myall Lakes appear to have much greater dependence on coleopterans (64% of stomachs occupied, mostly larvae), araneaeans (45%) and blattodeans (27%) which differs from the studies of Brown (1983) and Taylor (1986). However, our sample of only 10 *C. robustus* and 11 *C. taeniolatus* juveniles collected over only three days represents only a very isolated set of data while Brown (1983) and Taylor (1986) collected many more lizard stomachs, sampling regularly every few weeks for a number of years. So any detailed comparison between our data and that of Brown (1983) or Taylor (1986) should be made with caution.

The habits of the main prey items for *C. robustus* (adult coleopterans, hemipterans, isopterans and thomasidids) suggest that juvenile *C. robustus* may be foraging in the lower vegetation layer as well as on the ground, while those of the main prey items for juvenile *C. taeniolatus* (coleopteran larvae, neuropterans and lycosids) suggest that these skinks may be foraging mostly on the ground and digging for some prey. *Ctenotus taeniolatus* also had significantly more plant material in its diet than did *C. robustus*. But, as our data were collected in early April only, it is possible that there is a seasonal influence on diet so that these differences should be treated extremely carefully. Although the number of our samples is limited, they were collected at the time of the year when both *C. robustus* and *C. taeniolatus* juveniles are foraging on the same areas of the mining path. However, while there was a predominance of beetles (Coleoptera) in the diet of both species, prey items were recorded from nine to 11 different orders. This suggests that, in our study area, both these skinks are broad spectrum opportunistic insectivores. The separation in the diets of our juvenile skinks probably results from differences in the size of the skinks (*C. robustus* is approximately 1.4-fold heavier than C. taeniolatus). The dietary overlap of these skinks is therefore reduced as they are feeding on prey items which generally differ in size.

ACKNOWLEDGEMENTS

We thank Mr Roberto Inzunza, Mr Jia Luo, Ms Ann Lonergan and Ms Annette McGreavy for their assistance. This study was supported in part by ARGS grant number A18616300.

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